ACCOMPLISHMENT REPORT

PROPULSION DIRECTORATE
May 1999

DENMARK TO ADOPT JP-8+100: The Air Force's +100 fuel additive was a featured topic at the North Atlantic Treaty Organization (NATO) AC/112 (Aviation Fuels & Lubricants) Working Party Meeting held in Brussels, Belgium, in April 1999. At the meeting, Denmark announced its intention to convert the Royal Danish Air Force (RDAF) to operation on JP-8+100 fuel. The RDAF has already acquired the necessary funding to complete the conversion, and preparations to make the conversion are underway. Because of concerns about interoperability with other nations, Denmark plans to add the +100 additive to the fuel as it enters the aircraft using a specially modified pump. This will allow aircraft operating with or without the additive to be fueled from the same fuel truck. This procedure differs from that used by the US which injects the additive in the fuel as it enters the fuel truck. Testing of Denmark's additive injection system is scheduled to commence at the end of May 1999, and if these tests are successful, routine operation on JP-8+100 will begin in June 1999. The RDAF anticipates completing the conversion process by the end of 1999. The RDAF operates more than 100 aircraft with their primary aircraft being the F-16 Fighting Falcon. Other RDAF aircraft that will be operated on JP-8+100 include the C-130 Hercules, the Gulfstream G-III, and the Canadair CL-604 Challenger. In addition to Denmark's interest in JP-8+100, other nations expressed considerable interest in JP-8+100 at the NATO meeting. Among these nations, the United Kingdom, Germany, and Greece are planning to run engine tests with JP-8+100 in the near future. (P. Liberio, AFRL/PRSF, (937) 255-6918)

RDAF aircraft participating in the JP-8+100 conversion include (from top to bottom) the F-16, the C-130 Hercules, the Gulfstream G-III, and the Canadair CL-604 Challenger

ROMAR NAMED NCO OF THE YEAR: Staff Sergeant Gerald Romar was recently named AFRL's 1998 Non-Commissioned Officer (NCO) of the Year. At the ceremony to recognize SSgt Romar on 4 March 1999, AFRL's commander, Maj Gen Richard R. Paul, and the Chief Master Sergeant of the Air

Force, Robert D. Gaylor, honored him. SSgt Romar is an Experimental Rocket Engine Technician at the Propulsion Directorate's facilities at Edwards AFB, CA. He was selected as NCO of the Year for his numerous contributions to the research efforts at Edwards AFB. He used his extensive technical expertise to prevent critical safety hazards, saved thousands of dollars with innovative solutions to project problems, and helped complete numerous projects ahead of schedule. In one instance, his diagnostic skills enabled him to isolate and shut down a malfunctioning vacuum pump on the lab's unique high-altitude space environmental chamber. This action prevented serious damage to the $4 million space simulation facility. SSgt Romar is a worthy recipient of this award and a credit to the Propulsion Directorate. (J. Pearce, AFRL/PRO, (937) 255-5451)

SSgt Gerald Romar,
AFRL NCO of the Year

IHPTET MISSILE ENGINE TECHNOLOGY STEPS FORWARD: The first phase of testing of Williams International's Joint Expendable Turbine Engine Concept (JETEC) engine, the XTL-86, was completed in March 1999 at their facilities in Detroit, MI. The Williams JETEC demonstrator is pursuing the Integrated High Performance Turbine Engine Technology (IHPTET) Phase II goals for supersonic expendable engines: 45 percent cost reduction and 70 percent increase in specific thrust. The XTL-86 has two configurations. XTL-86/1 is an all-metallic configuration that has demonstrated a forward swept shrouded compressor, a high heat release combustor, and hybrid ceramic fuel-lubed bearings. XTL-86/2 includes an uncooled, high-temperature hot section with a carbon silicon-carbide (C/SiC) turbine rotor, C/SiC turbine nozzle, and a carbon-carbon (C/C) exhaust nozzle. XTL-86/1 established a fuel schedule for future demonstrations and ran from idle to 100 percent mechanical speed. Although the XTL-86/1 could not be tested supersonically, the sea level static results equate to a 40 percent increase in specific thrust compared to the baseline. This summer, XTL-86/2 will be tested at NASA Glenn Research Center (formerly NASA Lewis Research Center) in Cleveland at JETEC Phase II goal demonstration points for about 10 hours at Mach 1.0+. This new technology represents a 75 percent increase in cruise speed and about a 40 percent decrease in reaction time relative to the J402 engine. (Capt C. Cunningham, AFRL/PRTP, (937) 255-2767)

The Williams International XTL-86

ADVANCED THERMAL BATTERY FOR INTERCEPTOR MISSILE: Eagle-Picher Technologies, LLC, recently announced the development of a lightweight thermal battery using a strong titanium case and header. This battery, the EAP-12272, was Eagle-Picher's first thermal battery in a titanium case to be transitioned to a missile. The missile type is an Exo-atmospheric Kill Vehicle (EKV) interceptor missile. The technology development efforts for the titanium case and header (including dual-bead, glass-to-metal seals in the titanium header) were begun several months previously as a weight reduction subtask on a Battery Branch (AFRL/PRPB) contract titled, "Thermal Battery for Aircraft Emergency Power." The development work of this contract enabled the EAP-12272 to be designed, built, and flight-qualified in only 5 months. In addition, Eagle-Picher has performed numerous strength, flammability, and safety tests with the new titanium materials. The titanium hardware developed in this AFRL/PRPB contract was necessary for the battery to meet the extreme demands of very high energy levels in a very small, lightweight package. (D. Ryan, AFRL/PRPB, (937) 255-7770)

Titanium Cased Thermal Battery

PERFORMANCE PREDICTION OF PDE RESEARCH ENGINE THRUST: Combustion Branch (AFRL/PRSC) engineers recently completed a first-order thrust prediction for the in-house pulsed detonation engine (PDE). This prediction was based on data derived from an analysis supplied by the Applications & Assessments Branch (AFRL/PRST). Initial results are very promising predicting up to 700 lb_f of thrust from the current four tube engine design with each tube operating at 50 Hz. Remarkably, the engine that is the basis of this prediction was assembled for less than $2,000. With slight modifications to the engine valve system, the engine should produce about 1,200 lb_f thrust. The theoretical operating limit of the engine approaches 3,000 lb_f of thrust at just under 200 Hz. The experimental engine hardware is nearly assembled while the control software is still in a developmental stage. Experimental verification of thrust predictions will be possible as soon as the control software is operating. Initial experimental tests at low operating frequencies will produce substantial amounts of thrust and demonstrate the potential high performance and low cost possibilities of the PDE concept.

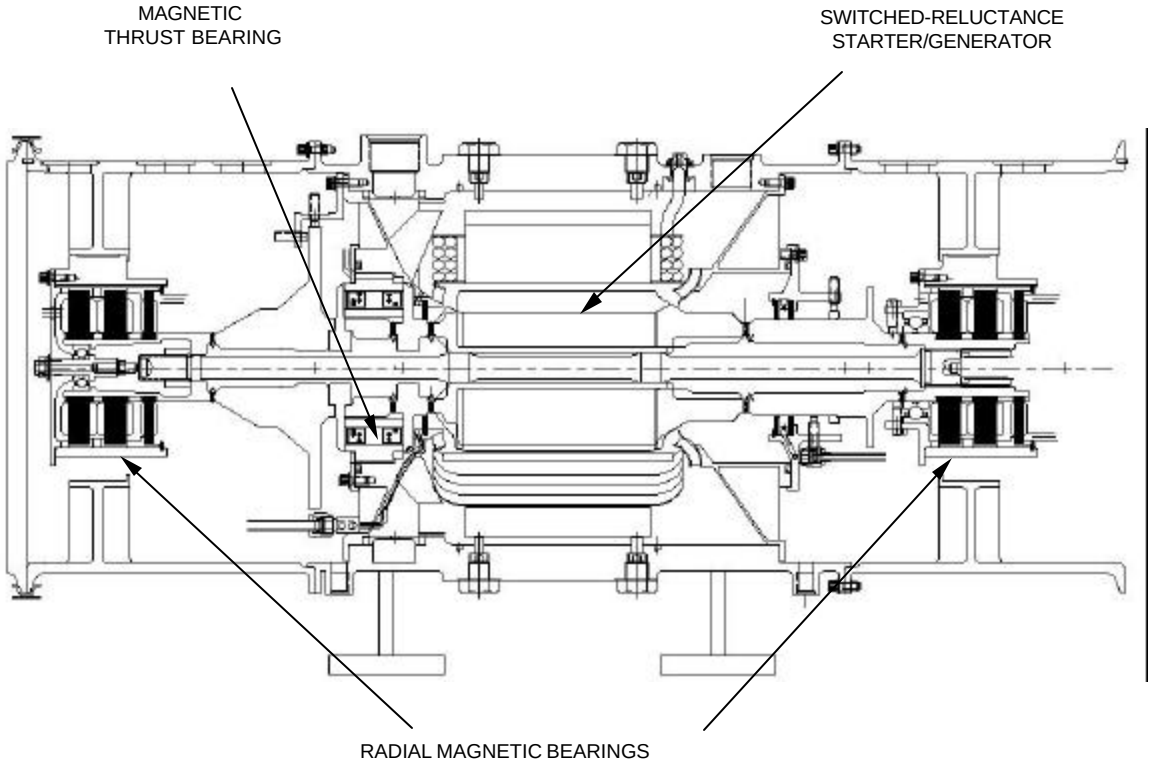
This preliminary performance analysis of the research engine demonstrates the exciting possibilities of the PDE concept. (F. Schauer, AFRL/PRSC, (937) 255-1945)

SMART ACTUATOR GETS PASSING GRADE: The High Temperature Distributed Control System (HiTeC) consortium has completed rig environmental testing and passive engine demonstration of a variable vane actuator control module that can operate uncooled up to 225°C (437°F). These tasks were completed in support of the HiTeC Program, a dual-use (military and commercial) technology development agreement awarded under the 1995 Technology Reinvestment Project solicitation sponsored by the Defense Advanced Research Projects Agency (DARPA). United Technologies Corp, acting through the United Technologies Research Center (UTRC), organized a 14-member consortium of leading aerospace companies and the University of Maryland to accomplish this effort. Other consortium members include Pratt & Whitney, Boeing Defense and Space Group, Rockwell Science Center, and various actuator and electronics suppliers. The high temperature actuator control module is the critical component for a distributed engine control system, which is the key to achieving Integrated High Performance Turbine Engine Technology (IHPTET) Phase III Controls and Accessories' objectives for reducing weight, production cost, and maintenance cost. The demonstration platform for the HiTeC smart actuator is Pratt & Whitney's XTE66. Prior to resumption of engine testing, Pratt & Whitney technicians will replace the fan variable vane actuator currently installed on the engine with the smart actuator. The next sequence of tests will take place with the new actuator actively controlling fan variable geometry. This will be the first-ever demonstration of a high temperature smart component on an aircraft engine and a significant milestone on the path to a fully distributed control system. (T. Lewis, AFRL/PRTA, (937) 255-6690)

THREAT PROGRAM TASTES SUCCESS: The Tactical Hybrid Rocket Engine Applied Technology (THREAT) Program recently got a taste of success. In April 1999, the THREAT program successfully test-fired a sub-scale hybrid rocket motor at Thiokol's Elkton, MD test facility. The hybrid rocket motor used a HAN (hydroxyl ammonium nitrate) based oxidizer and a HTPB/AP (hydroxy-terminated polybutadiene/ammonium perchlorate) based fuel grain. The motor successfully fired for duration of approximately 2 seconds. This motor firing supports the Rocket Propulsion Division's (AFRL/PRR) ongoing cooperative technology efforts with Japan. (L. Quinn, AFRL/PRR, (661) 275-5630)

IPU TECH DEMO BEGINS TESTS: Power Division (AFRL/PRP) personnel recently visited AlliedSignal Engines to witness the initial testing of the Technology Demonstrator for the More Electric Aircraft (MEA) Integrated Power Unit (IPU) Program. The MEA IPU Program has focused on developing two key technologies: (1) an air-cooled starter/generator (switched reluctance machine or SRM) supported by (2) non-lubricated (magnetic) bearings. These two technologies are central to demonstrating increased IPU reliability and reduced ground support equipment requirements. The final Technology Demonstrator (or Tech Demo) rig integrates the noted technologies for the first time in a combined test. Previous subsystem testing resulted in the successful demonstration of 140 kW peak generator power at the rated speed of 55 krpm (design of 125 kW continuous with 250 kW peak), and magnetic bearings operating at 54.5 krpm maximum speed on a separate simulated IPU rotor rig. The Tech Demo is being used as a test bed to provide initial insight into the interactions between the SRM and the magnetic bearing rotor support system. The Tech Demo was checked out to 30 krpm while

providing 30 kW of power at 270 VDC. Overall, the Tech Demo speed will be limited to below 45 krpm because of rotor dynamic response near the first bending critical speed. This limitation is the result of the relatively "soft" rotor section of the SRM. The MEA IPU Program is expected to finish quickly with the hardware to be transferred to an AlliedSignal Dual-Use program. (E. Hoffman, AFRL/PRPG, (937) 255-6241)



IPU Technology Demonstrator Rig

POLISH FUELS & LUBES LABS TO IMPLEMENT US PRACTICES: Poland recently announced its intention to model its fuels and lubrication laboratories after those operated by the US Air Force at Wright-Patterson AFB (WPAFB). This announcement was made at the recent North Atlantic Treaty Organization (NATO) AC/112 (Aviation Fuels & Lubricants) Working Party Meeting held in Brussels, Belgium, in April 1999. A Polish delegation, led by Col Bonczek, was hosted by AFRL/PRS at WPAFB last year for a "fuels and lubrication familiarization event." During their visit they reviewed research efforts being performed by PRS and toured the fuel qualification laboratory operated by the San Antonio Air Logistics Center (SA-ALC/SFT). Impressed by what he saw, Col Bonczek briefed his superiors on the way business was conducted by USAF laboratories and presented a plan to revamp Polish laboratories. The goal of this plan, which was recently approved, is to restructure Poland's fuels

and lubrication laboratories to reflect the organizational structure and mission of the laboratories at WPAFB. This will help elevate Poland's fuels and lubrication technology to the standards of other NATO allies and alleviate concerns about interoperability with Polish forces. Col Bonczek also announced his intention of inviting US fuels and lubrication experts to visit Poland's new laboratories later this summer to provide guidance on Poland's restructuring activities. The official invitation letter is expected in a few weeks with Dr. Bob Wright (PRSL), Ms. Patricia Liberio (PRSF), and Dr. Shashi Sharma (MLBT) as the invitees. (R. Wright, AFRL/PRSL, (937) 255-5568 and P. Liberio, AFRL/PRSF, (937) 255-6918)

UNIQUE TURBINE TESTING CAPABILITY DEMONSTRATED: Air Force personnel recently completed testing for the Advanced High-Work Turbine (AHWT) test program at the Turbine Research Facility (TRF) at Wright-Patterson AFB. This test program was a major success, not only for the research objectives obtained, but also for the test capabilities demonstrated in the TRF. The AHWT represents a major milestone towards the achievement of Integrated High Performance Turbine Engine Technology (IHPTET) Phase II turbine objectives, including increasing turbine inlet temperature by 600°F, decreasing cooling flow by 35 percent, increasing efficiency by 2 percent, and increasing turbine work by 30 percent. The AHWT test program was the first complete program to utilize all of the testing capabilities of the TRF. The turbine stage was first tested in a vane-only configuration, and then in the full vane-rotor stage arrangement. In both configurations a full complement of aerodynamic and thermodynamic data were obtained. Several new testing capabilities were also demonstrated including a highly successful active feedback speed control. Future testing includes the F119 rotor stage test (vane test was completed earlier) to be followed by a cooled version using Component and Engine Structural Assessment Research (CAESAR) hardware. The ability to add cooling flows is a new TRF capability currently under development. This and other ongoing improvements in the TRF will allow current and future rotor technologies to be thoroughly tested and analyzed in order to reach IHPTET Phase III objectives and beyond. (D. Hoying, AFRL/PRTE, (937) 255-6802)

Advanced High-Work Turbine

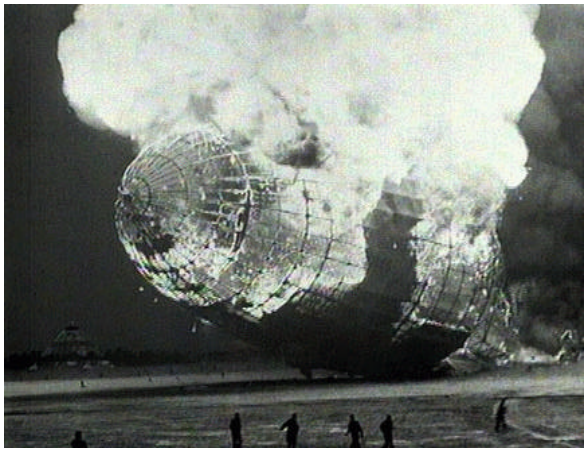


Photo from the 1937 Hindenburg disaster

ASSISTING THE HINDENBURG DISASTER INVESTIGATION: In February, Larry Walko, Dr. Dan Schweickart, and John Horwath of the Power

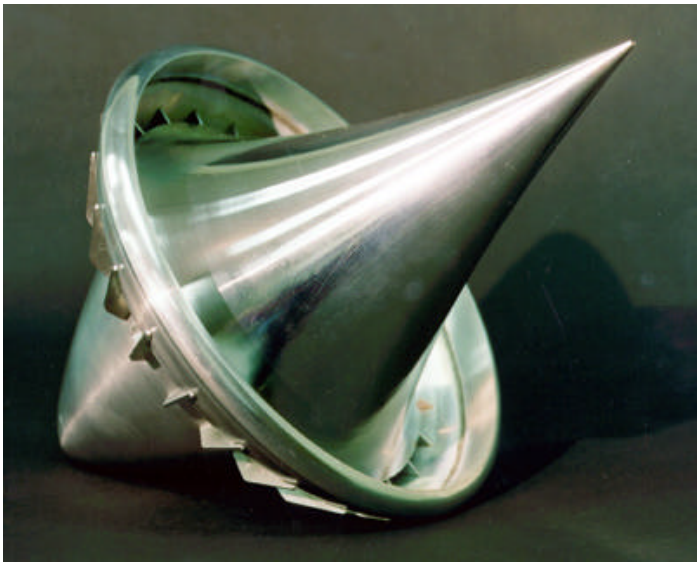
Division (AFRL/PRP) met with Dan Clifton (from a film documentary company affiliated with the British Public Broadcasting company) in regards to a TV program being prepared for British Public Broadcasting. The topic of this program is the Hindenburg airship disaster that occurred in May 1937 in Lakehurst, NJ. It has long been accepted that ignition of the hydrogen gas from high voltage static discharge was the initial cause of the fire and subsequent destruction of the airship. A new theory asserts that the static charge actually ignited the doped fabric covering of the airship. A cellulose nitrate dope with powdered aluminum may have been used on the Hindenburg. For his documentary, Mr. Clifton was interested in obtaining information on static charge buildup and atmospheric phenomena. He was given a tour of PRP test facilities and a demonstration of corona generated on a circuit that John Horwath has set up for his doctoral work. Mr. Clifton returned in March 1999 with a film crew and interviewed Walko, Schweickart, and Horwath and taped simulated lightning tests and additional corona simulations. The documentary is scheduled to be aired this summer in the UK and sometime later in the US through WNET (NY). (L. Walko, AFRL/PRPS, (937) 255-9634)

SOLID BOOST DEMO PROGRAM PDRs: Thiokol recently conducted two Preliminary Design Reviews (PDR) for the Integrated High Payoff Rocket Propulsion Technology (IHPRPT) Phase I Solid Boost Demo Program. These reviews were held at Thiokol's Wasatch, UT facility on 28-29 April 1999. The motor case PDR focused on lower-cost, alternative case and insulation materials to the ones used on the baseline Castor 120 motor. Currently, Thiokol has evaluated each of the potential substitutes and is in the process of making a selection. The second PDR was for a lower-cost, lower-weight actuator to provide nozzle thrust vector control (TVC). Moog International Controls Group, under a subcontract to Thiokol, is performing this work. Moog's design utilizes an electromechanical actuator that will replace the hydraulic actuator currently used on the Castor 120. The objective of this Rocket Propulsion Division (AFRL/PRR) sponsored program is to demonstrate Phase I IHPRPT goals for a space launch solid propellant booster. (L. Quinn, AFRL/PRR, (661) 275-5630)

CAESAR: 1,500 CYCLES COMPLETED: The Component and Engine Structural Assessment Research (CAESAR) program engine test has now completed 1,591 of a planned 2,000 TAC cycles. CAESAR is part of the Integrated High Performance Turbine Engine Technology (IHPTET) engine durability effort. Prior to completing the remaining 500 TAC cycles, Pratt & Whitney requested that they be allowed to demonstrate an inlet rake for the F-22 flight program. During this demonstration, a bolt came loose, entered the CAESAR engine, and did significant damage to the fan and compressor. Fortunately, Pratt & Whitney reports that the hot section parts received little or no damage from this incident. Pratt & Whitney plans to rebuild the engine and complete the remaining 500 TAC cycles. The gamma titanium aluminide compressor blades that were being tested in CAESAR will not be part of the rebuild. Instead, these blades will be returned to Wright Patterson AFB for testing in the new Turbine Engine Fatigue Facility (TEFF). These blades will be examined for damage and will subsequently be run through several tests until they fail. The test-to-failure will allow the Air Force to identify how much residual life the blades have left. (M. Huffman, AFRL/PRTP, (937) 255-2278)

MORE LIGHTCRAFT PRESS COVERAGE: Lee Dye's 21 April 1999 Science Column for the ABC News web site featured the laser-propelled Lightcraft being developed by the Propulsion Directorate. The column, titled "Riding Lasers into Space," examines Lightcraft creator Dr. Leik Myrabo's vision for

the future of laser propulsion. Within about 5 years, Dr. Myrabo envisions small satellites being placed into orbit using laser propulsion. In the far-term, Dr. Myrabo believes that humans will travel into space on laser powered ships, with a journey to the moon taking a little more than 5 hours. Currently, AFRL/PR and NASA Marshall Space Flight Center are supporting Lightcraft research being performed by Rensselaer Polytechnic Institute. (J. Pearce, AFRL/PRO, (937) 255-5451)
[see article at http://more.abcnews.go.com/sections/science/DyeHard/dye990421.html]



A Lightcraft model

RESEARCH FOR PLASMA ENHANCED SEMICONDUCTOR MANUFACTURING: AFRL/PRPS recently signed a CRADA (Cooperative Research and Development Agreement) with the California Institute of Technology (Cal Tech) to establish a cooperative study of electron impact ionization of gases used in semiconductor processing. Cal Tech receives money from SEMATECH (SEmiconductor MAnufacturing TECHnology), a non-profit R&D consortium of US semiconductor manufacturers, for theoretical calculations of ionization cross sections in gases primarily used in semiconductor etching. AFRL/PRPS has a significant 6.1 program, funded by AFOSR, for measurement of ionization cross sections and ion-molecule reaction rates in gases used in Plasma Processing applications relevant to future Air Force needs. Motivation for the CRADA came as a result of Cal Tech approaching AFRL/PRPS to perform experimental measurements of various ionization processes in a number of gases that are seen as potential etchants for future electronics fabrication. While most of these gases are used in high density silicon electronics fabrication, some find application in the area of high temperature, high power, radiation hard electronics which has direct application to future Air Force power systems. Also, in exchange for measurements by AFRL/PRPS of etchants relevant to traditional silicon electronics fabrication, Cal Tech will supply theoretical calculations to support measurements on gases relevant to power electronics applications. (C. DeJoseph, AFRL/PRPS, (937) 255-2923)

PRR SUPPORTS NAVY'S TESTING: Rocket Propulsion Division (AFRL/PRR) personnel continued test planning and coordination for testing of the Navy's Standard Missile-3 (SM-3) Kinetic Warhead. The SM-3 is a component of the Navy Theater Wide (NTW) defense system that is being developed in response to the vulnerability of US forces and populations to the threat from ballistic missile attack. The mission of the NTW is to provide upper-tier protection against long-range threats. PRR continues to prepare for testing of NTW systems. The NTW target and background are ready for IR signature testing which will commence in May 1999. The National Hover Test Facility (NHTF) is currently increasing data acquisition system capability to meet the additional requirements needed by the NTW test team. Additional accelerometer data will be acquired during the System Integration Test (SIT) to aid in determining the self-induced vibrational modes of the kinetic warhead. The NTW SIT test is scheduled to begin in September 1999, while the NTW hover test is scheduled for November 1999. (L. Quinn, AFRL/PRR, (661) 275-5630)

MORE SYSTEMS CONSIDERING JP-8+100 CONVERSION: The Fuels Branch (AFRL/PRSF) is undertaking efforts to field JP-8+100 in more Air Force systems. The focus of recent efforts is on converting the B-1B and the C-17. A meeting was recently held with the B-1 Systems Program Office (ASC/YD) on the potential field demonstration of JP-8+100 in the B-1B Lancer. The B-1B is experiencing increased augmentor spraybar coking due to problems with a newly retrofitted design. It is believed that JP-8+100 can considerably reduce the coking in this component. Prior to converting the B-1B to JP-8+100, the affected components will have to be cleaned in order to collect meaningful data. PRSF will provide technical support as required to prepare a test plan for testing the B-1B's F101 engine at General Electric's Evendale facility. PRSF will also support an aircraft field evaluation at Mt Home AFB, ID. A meeting was also recently held with the C-17 SPO (ASC/YC) related to the field evaluation of JP-8+100 in the C-17 Globemaster III. The SPO is exploring the feasibility of the field evaluation to determine the effect of +100 on reducing particulate emissions. The +100 additive has been shown to significantly reduce particulate emissions. PRSF will provide technical support to the ASC/YC as needed to assist in this investigation. (W. Harrison, AFRL/PRSF, (937) 255-6601)

Two new candidates for JP-8+100 conversion: the B-1B (left) and the C-17 (right)

POWER DIVISION CONTRACTOR SELECTED AS 1998 GRAND PRIZE WINNER: American Superconductor Corp (ASC) was selected as the 1998 Grand Prize Winner at the annual TechEast

Conference. The conference is sponsored by the Technology Utilization Foundation in cooperation with all federal agencies and departments that participate in the SBIR Program. Awards presented at the conference recognize companies that have developed important new commercial products and services through the SBIR Program. The award was presented to ASC for its development and manufacture of high temperature superconducting components. ASC has been awarded several SBIR programs from the Air Force and Ballistic Missile Defense Organization (BMDO) which are managed by the Propulsion Superconductivity Group, which includes personnel from the Power Division (AFRL/PRP). One of the programs is to develop actively cooled power supplies for radar systems. The goal is reduction in the size and weight of ground-based radar systems by building a prototype power conditioning system using patented CryoPower converters. ASC achieved 30 percent savings in prime power for the radar system. (P. Barnes, AFRL/PRPS, (937) 255-2923)